Physics Laboratory Mirrors

Objective: To use ray tracing to discover and explain how different types of images are created with plane, concave and convex mirrors.

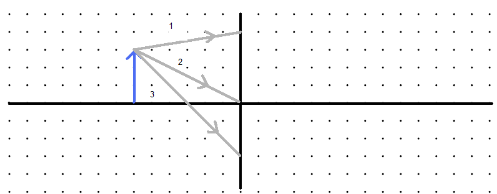
Materials: Laser Ray Box & Lenses, Arbor Scientific Product ID: P2-7680,
Mega Mirrors, Arbor Scientific Product ID: P2-7150
Diagram Sheets

The Law of Reflection states that the angle of incidence is equal to the angle of reflection. We will use ray tracing to predict the location and image characteristics for flat and curved mirrors.

Plane (Flat) Mirrors – Place the flat mirror on top of the vertical line on the diagram page. Be sure to line up the reflecting surface with the vertical line.

To find where the image of the arrow tip will be, point the single laser beam along each of the shaded lines (representing light rays that come from the arrow tip) and trace the reflected ray you see on the diagram paper.

Draw all diagrams on the diagram sheet and answer the questions in your lab notebook.



Q1.1 Do the reflected rays intersect?

Remove the mirror, and trace the reflected rays back to the other side of the mirror using dashed lines.

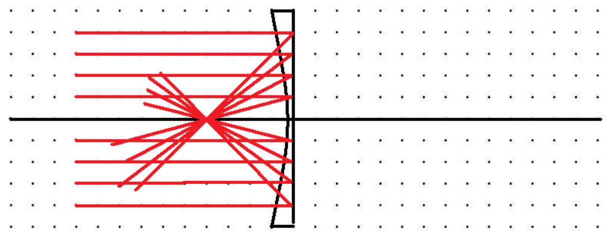
Where the dashed lines meet is where we see the image. This type of image is called a **virtual** image, because the light rays do not really intersect.

Q1.2 How tall is the image of the arrow? Measure the height of the intersection point from the principal axis. Is the image of the arrow tip at the same height as the original?

Q1.3 Is the image upright or upside down? If the arrow tip image is above the principal axis, your image is **upright**, if it is below the principal axis your image is **inverted**.

Q1.4 How do the predictions of the image characteristics from ray tracing compare to what you actually see when you look into a plane mirror?

Concave Mirrors – Gently bend the flexible mirror into a curved shape.   Use the adjustment screws to hold it in place.



1. A concave mirror will converge parallel light rays to a point called the *focal point* of the lens.
2. Try this with your mirror on the diagram sheet. Trace the incident and reflected rays that you see.

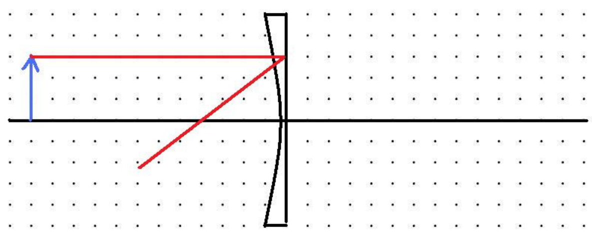
Q2.1 Measure and record the distance from the center of the mirror to the focal point.

A concave mirror forms images with different characteristics depending on where the object is located relative to the focal point of the lens.

There is a concave mirror in the back of the classroom (the one with the thick grey band around it). How do you see yourself when you are far from the mirror? Why does this occur? You will be able to answer this question after you complete this lab.

For a concave mirror, there are three **principal light rays**:

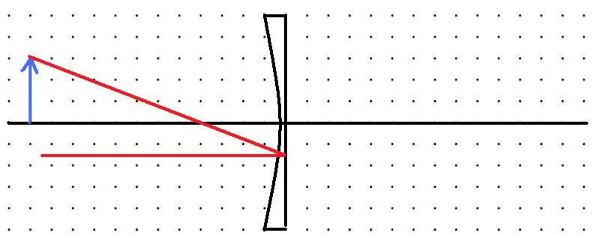
1. A ray approaching the lens parallel to the principal axis will be reflected through the focal point.



Using Diagram 3, draw an object arrow that is near the left side of the grid, similar to the figure at left.

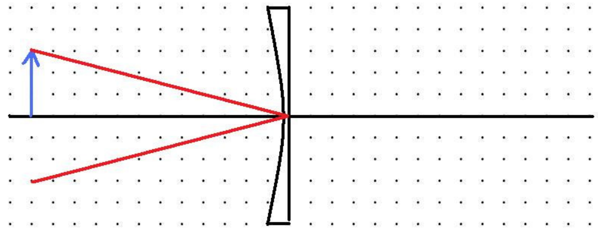
Try this on your diagram sheet using Diagram 3. Trace the incident and reflected rays and label them as “1”.

2. A ray approaching the mirror through the focal point will be reflected parallel to the principal axis.



Try this on your diagram sheet using Diagram 3. Trace the incident and reflected rays and label them as “2”.

3. A ray that hits the center of the mirror will obey the law of reflection.

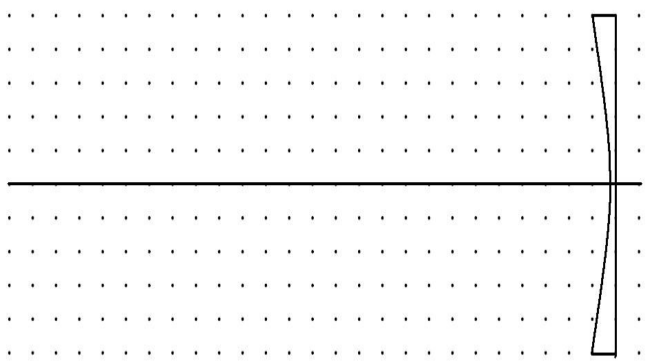


Try this on your diagram sheet using Diagram 3. Trace the incident and reflected rays and label them as “3”

Using these principal rays, five different types of images can be demonstrated.

Forming a real image with a concave mirror. A **real image** is formed by the intersection of light rays.

1. **Case 1** – An object very far from a concave mirror. Using Diagram 4, draw an object arrow at the far left of the diagram. Use the laser to create the three principal rays. Trace each incident and reflected ray on its way to and from the mirror. Start each ray from the tip of the arrow. Use a ruler.
    a. The image of the tip of the arrow is formed where the rays intersect.
    b. If the arrow tip image is above the principal axis, your image is **upright**, if it is below the principal axis your image is **inverted**.
    c. Draw the image of the arrow by drawing a vertical line from the location of the image of the arrow tip to the horizontal line.
    d. Classify the image on your diagram.

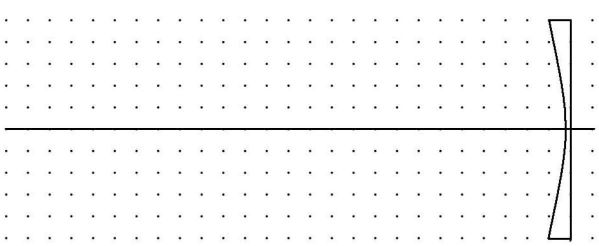


Real (light rays intersect) or **Virtual** (light rays do not intersect)?

Upright (image of arrow tip above horizontal line) or **Inverted** (image of arrow tip below horizontal line)?

Magnified (image is larger than object), **Reduced** (image is smaller than object) or **Same Size**

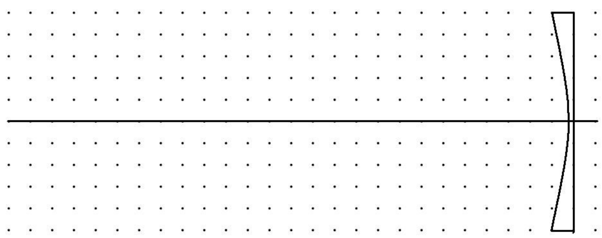
2. **Moving the object closer to the mirror. Case 2** – An object is two focal lengths from a concave mirror. Use Diagram 5. Draw an object arrow at a distance from the mirror equal to twice the focal length. Use the laser to create the three principal rays. Trace each ray on its way to and from the mirror. Start each ray from the tip of the arrow. Use a ruler.



    a. The image of the tip of the arrow is formed where the rays intersect.
    b. If the arrow tip image is above the principal axis, your image is **upright**, if it is below the principal axis your image is **inverted**.
    c. Draw the image of the arrow.

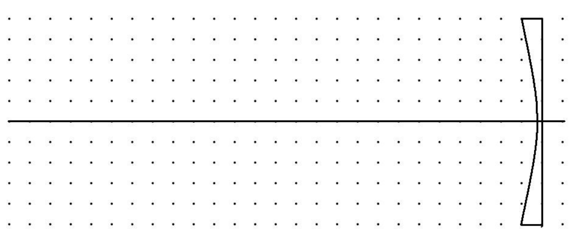
Classify the image on your diagram using the same terms as listed under case 1.

3. **Moving the object closer to the mirror. Case 3** – An object is between one and two focal lengths from a concave mirror. Use Diagram 6 and draw an object arrow at a distance from the mirror equal to 1.5 focal lengths. Use the laser to create each of the three principal rays to predict where the image will be located. Start each ray from the tip of the arrow. Use a ruler.



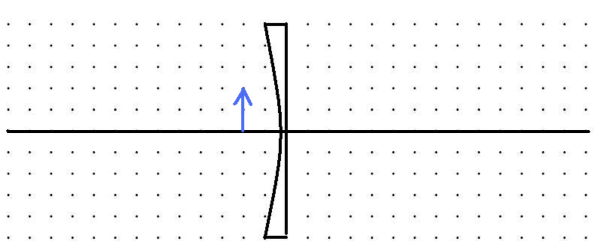
   a. The image of the tip of the arrow is formed where the rays intersect.
   b. If the arrow tip image is above the principal axis, your image is **upright**, if it is below the principal axis your image is **inverted**.
   c. Draw the image of the arrow.
      i. Classify the image using the same terms as in Case 1.

4. **Moving the object closer to the mirror. Case 4** – An object exactly one focal length from a concave mirror. Use Diagram 7 and draw an object arrow at a distance equal to the focal length from the lens. Use the laser to create principal rays #1 and #3 to predict where the image will be located (#2 cannot be drawn for this case). Start each ray from the tip of the arrow. Use a ruler.



Q7.1 There is no image formed in this case. Why?

5. **Moving the object closer to the mirror. Case 5** – An object is within one focal length of a concave mirror. Using Diagram 8, draw an object arrow half the focal length distance from the mirror.
   a. Use the laser to create principal rays #1 and #3 to predict where the image will be located.
   b. Principal ray #2 can be drawn, but it is a bit tricky. To draw principal ray #2, line up your arrow with the focal point and the arrow tip. Draw a ray that travels as if it came from the focal point to the arrow tip and then to the lens. That ray will be reflected parallel to the principal axis. Use a ruler.
   c. At this object position, the reflected light rays do not intersect. Use the technique described for the plane mirror to locate the image that is seen behind the mirror.
   d. Classify the image.



Use the table at the bottom of the diagram page to summarize the results of this activity. For object distance, count the number of boxes that the object arrow is from the mirror. For image distance, count the number of boxes that the image arrow is from the mirror.

Q 8.1 How many of the different cases can you observe in the large concave mirror in the classroom?

Q8.2 Use what you have learned in this activity to estimate the focal length of the big demo concave mirror. Give your estimate and explain how you determined it.

The Convex Mirror

You may have noticed that there is also a large convex mirror in the classroom.

Q9.1 What types of images do you see in this mirror? Is it possible to get both real and virtual images with a convex mirror?

Use your ray box and some grid paper to figure out why the convex mirror creates these types of images. Try to find some principal rays for the convex mirror. Hint: See what happens to rays that are incident to the mirror parallel to the axis. How can you make a ray reflect off of the mirror and be parallel to the axis?

Q9.2 Sketch your principal rays for the convex mirror.

Q9.3 Use your principal rays to show where the image of an object arrow tip would be formed.

Diagram 1 –Plane(Flat) Mirror

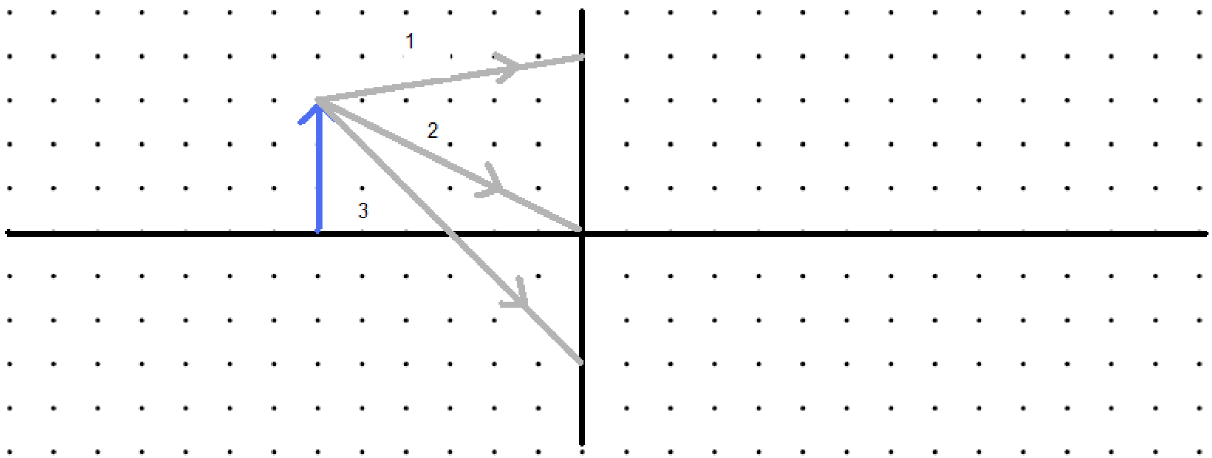


Diagram 2 – Parallel Rays of Light Striking a Concave Mirror

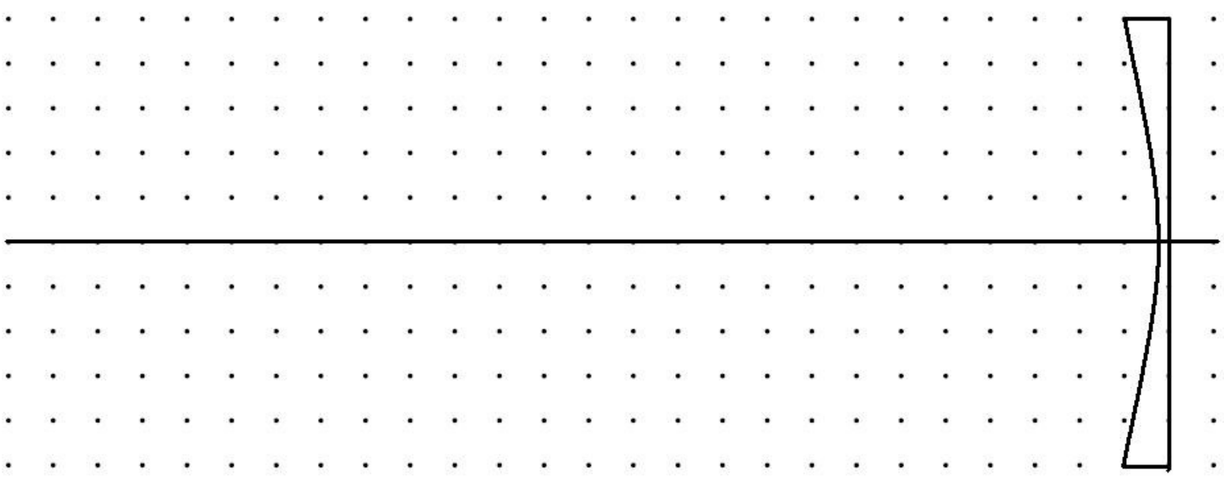


Diagram 3 – Three Principal Rays

Diagram 4 – An object very far from a concave mirror

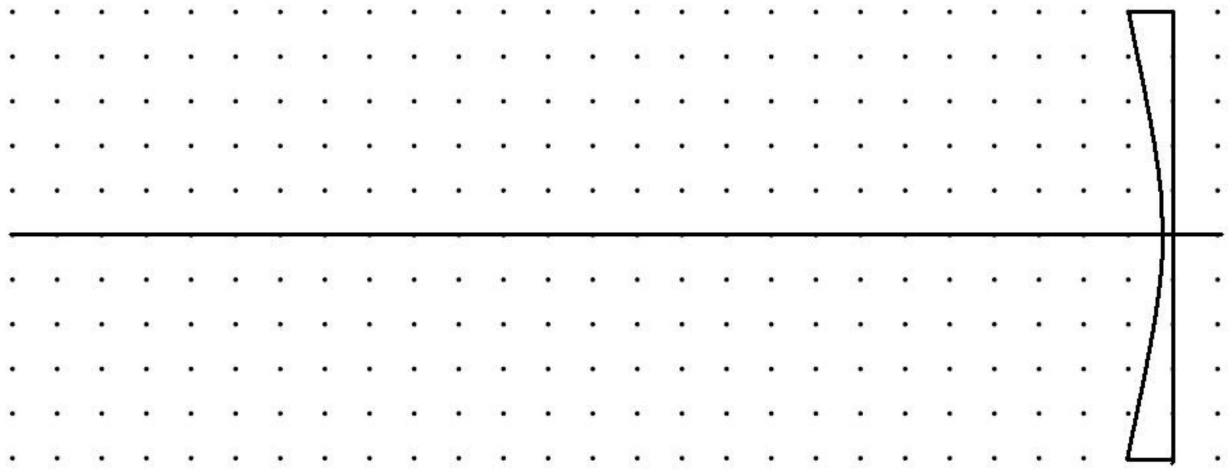


Diagram 5 – An object two focal lengths away from a concave mirror

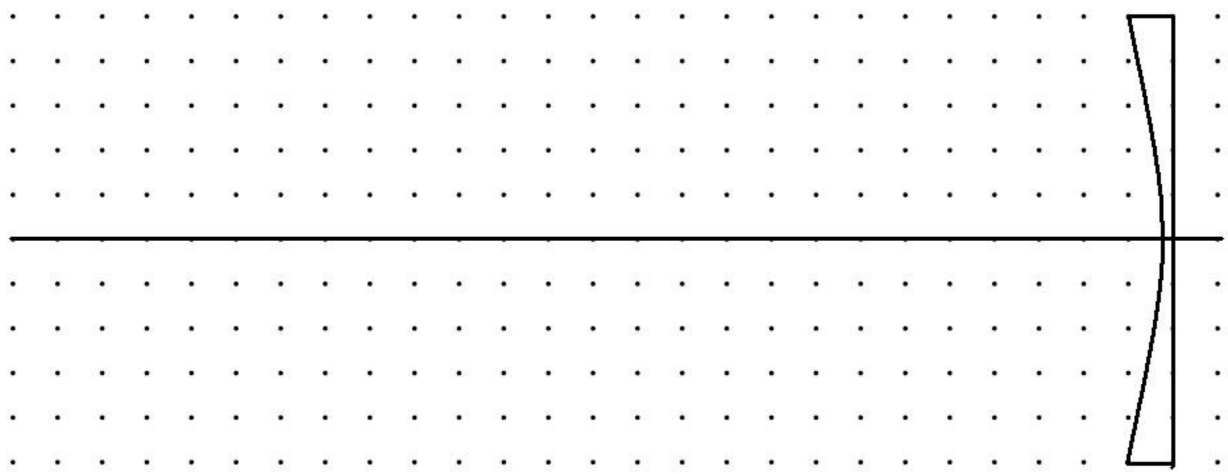


Diagram 6 – An object between one and two focal lengths away from a concave mirror.

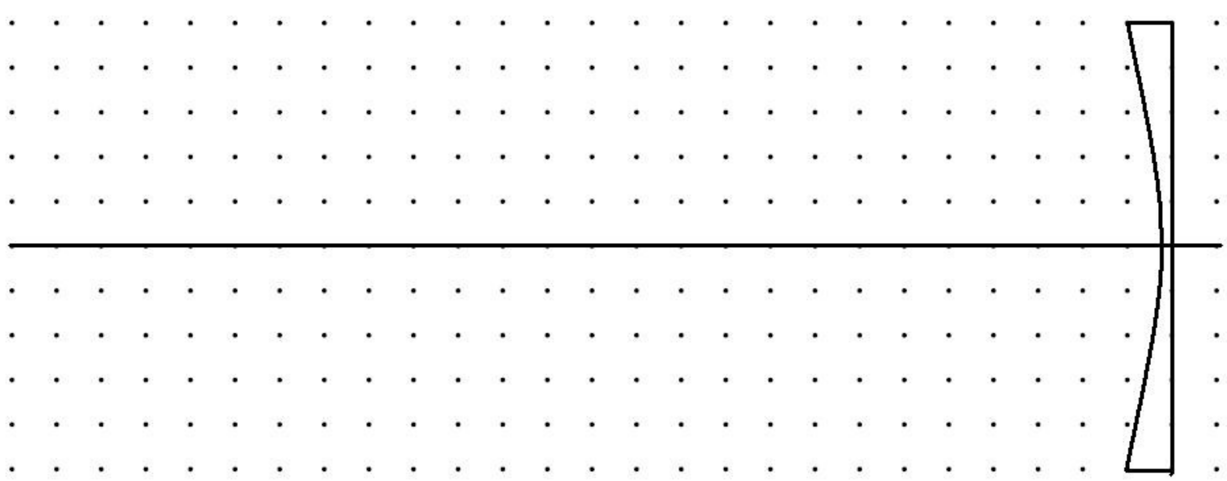


Diagram 7 – An object located at the focal length.

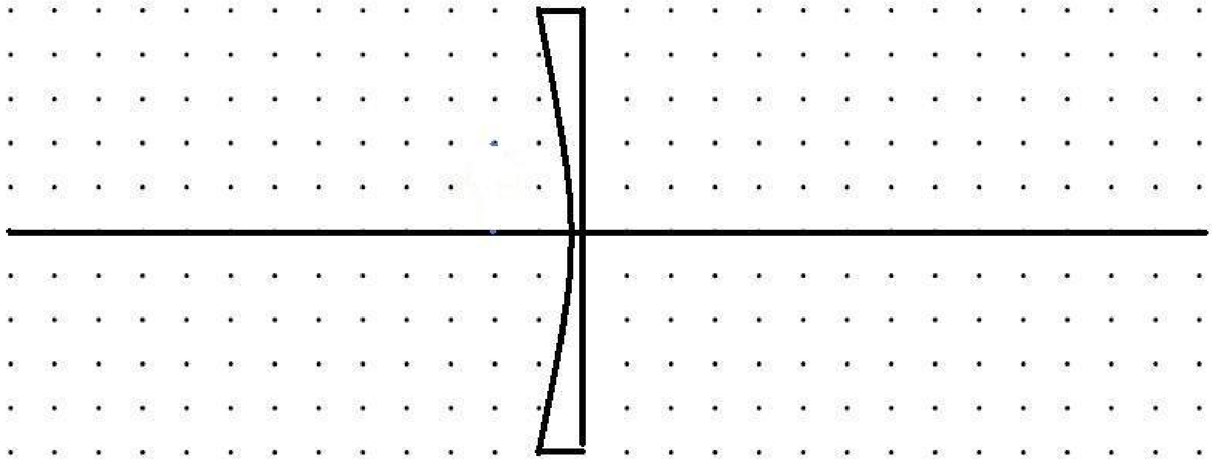
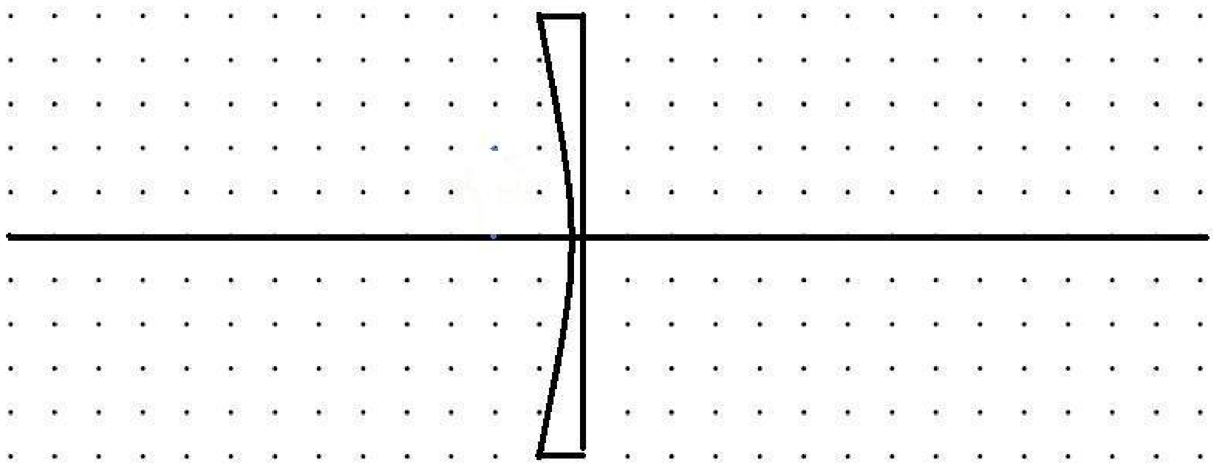


Diagram 8 – An object closer than the focal length.



Summary of Images formed by Concave Mirrors

Focal length of concave mirror = ________________

Case	**Object Distance**	**Image Location**	**Virtual/Real**	**Upright/Inverted**	**Larger/Smaller**
>2f					
2f					
Between f and 2f					
At f					
Between f and mirror					

Diagram 9 – Convex Mirror- Parallel Rays

Diagram 10 – Convex Mirror Principal Rays

Diagram 11 –Convex Mirror Image Formation